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Grabinger et al.

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(54) **WIRELESS ACTUATOR INTERFACE**

(75) Inventors: **Cory L. Grabinger**, Maple Grove, MN (US); **Mark D. Bokusky**, Brooklyn Park, MN (US)

(73) Assignee: **Honeywell International, Inc.**, Morristown, NJ (US)

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H01L 41/09 (2006.01)

(52) **U.S. Cl.** **310/317**

(58) **Field of Classification Search** 310/317
See application file for complete search history.

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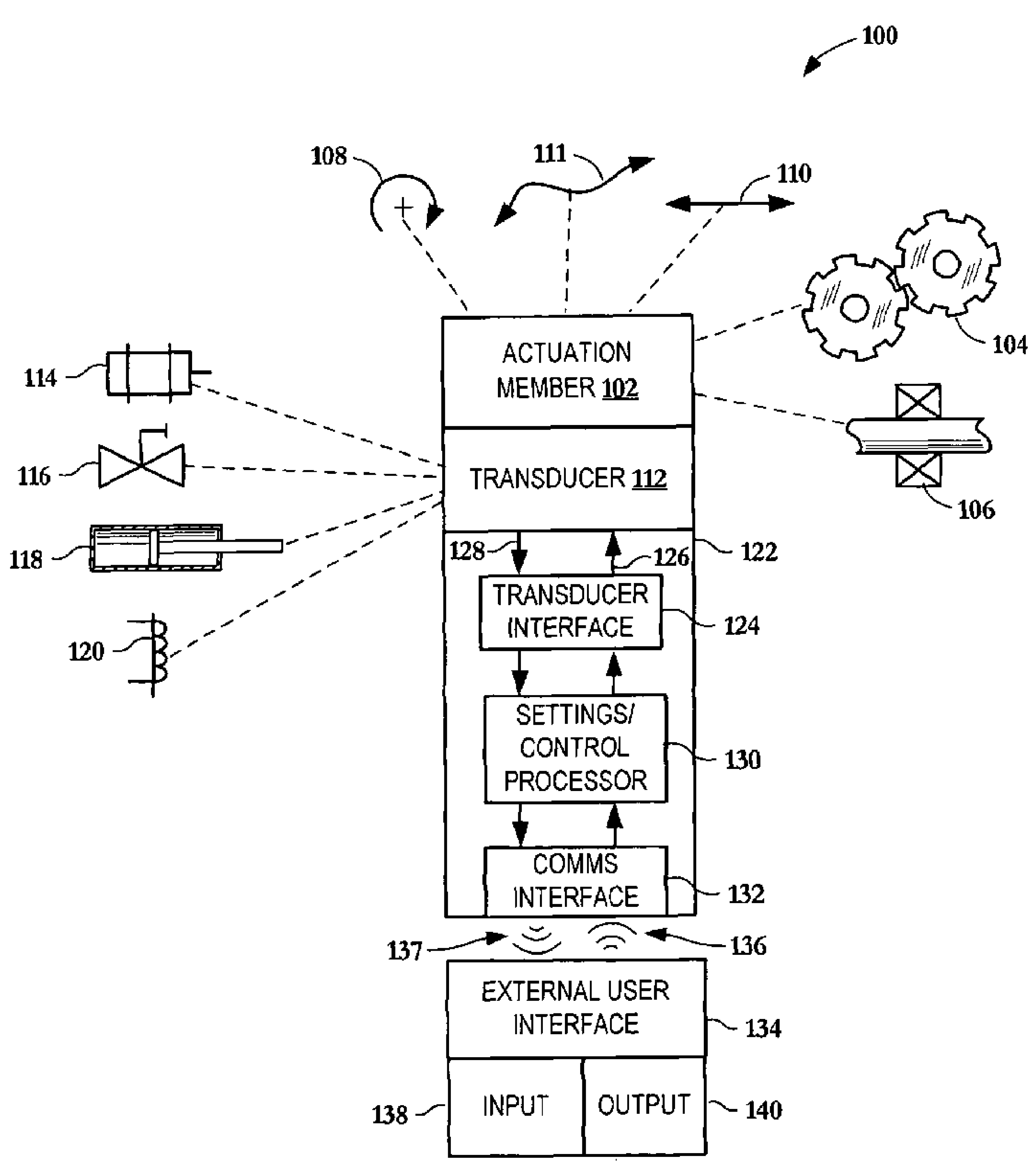
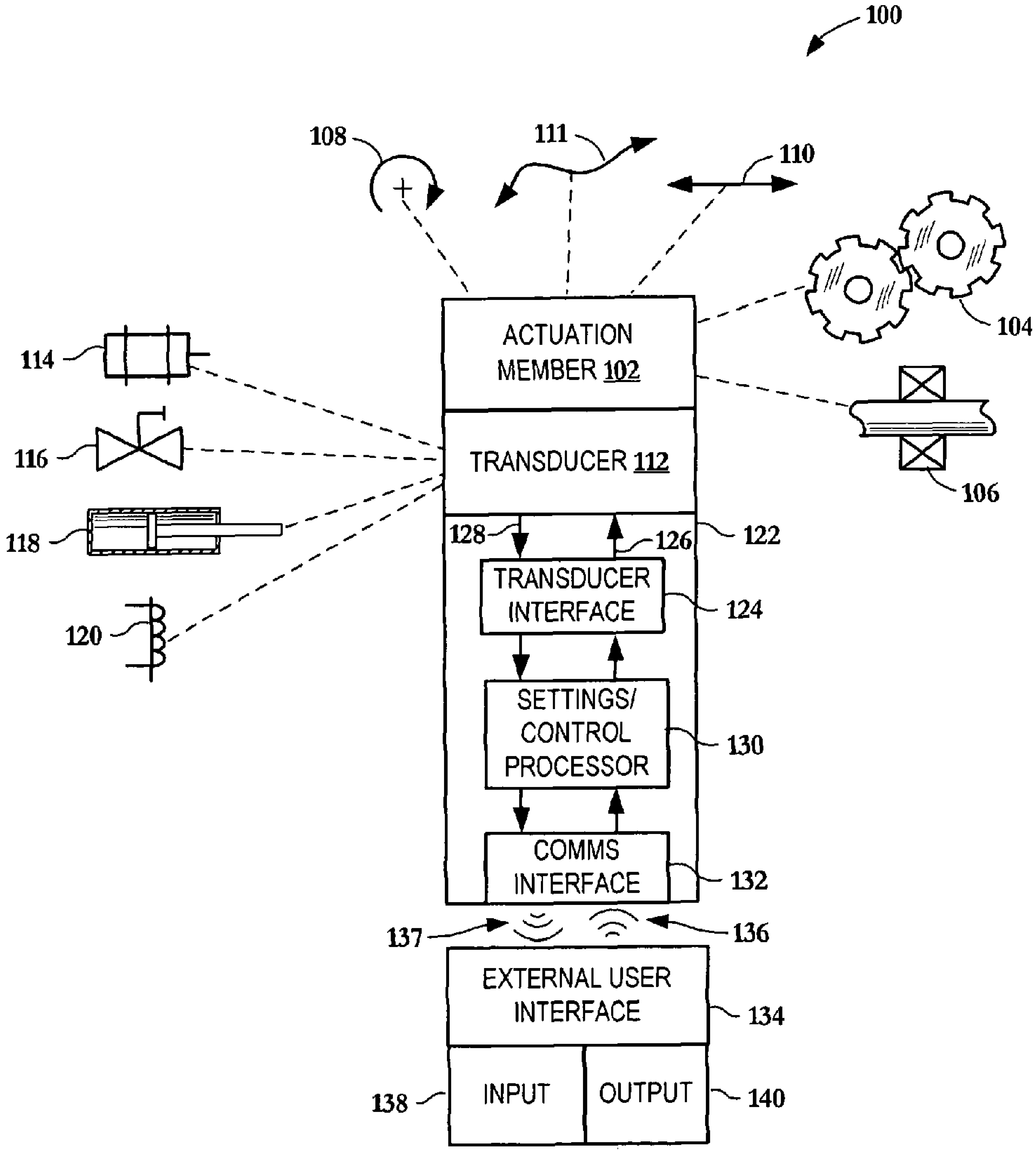
Primary Examiner — Derek J Rosenau
(74) *Attorney, Agent, or Firm* — Hollingsworth & Funk, LLC

(57) **ABSTRACT**

An actuator includes a mechanical transducer component capable of applying a mechanical force to an external object in response to electronic signals. The actuator includes a communications interface capable of wirelessly receiving configuration data related to operation of the actuator. A settings module is coupled to the communications interface and capable of storing the configuration data. A controller unit is coupled to the mechanical transducer and the settings module. The controller unit is capable of determining the configuration data via the settings module and controlling the mechanical transducer in conformance with the configuration settings.

26 Claims, 8 Drawing Sheets





100
108
111
110
104
106
114
116
118
120
ACTUATION MEMBER 102
TRANSDUCER 112
128
126
122
TRANSDUCER INTERFACE
124
SETTINGS/ CONTROL PROCESSOR
130
COMMS INTERFACE
132
137
136
EXTERNAL USER INTERFACE
134
INPUT
OUTPUT
138
140

FIG. 1

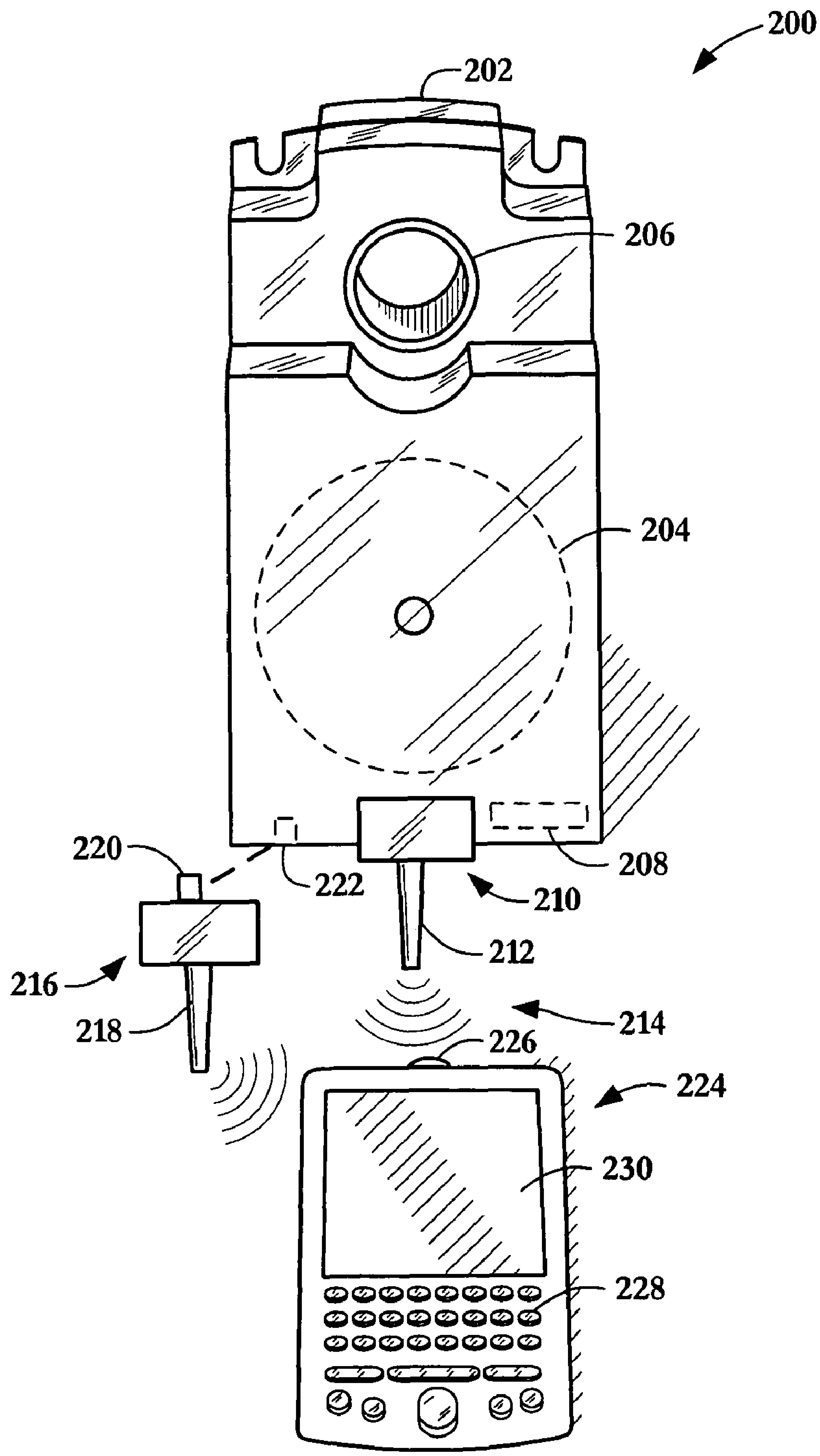


FIG. 2

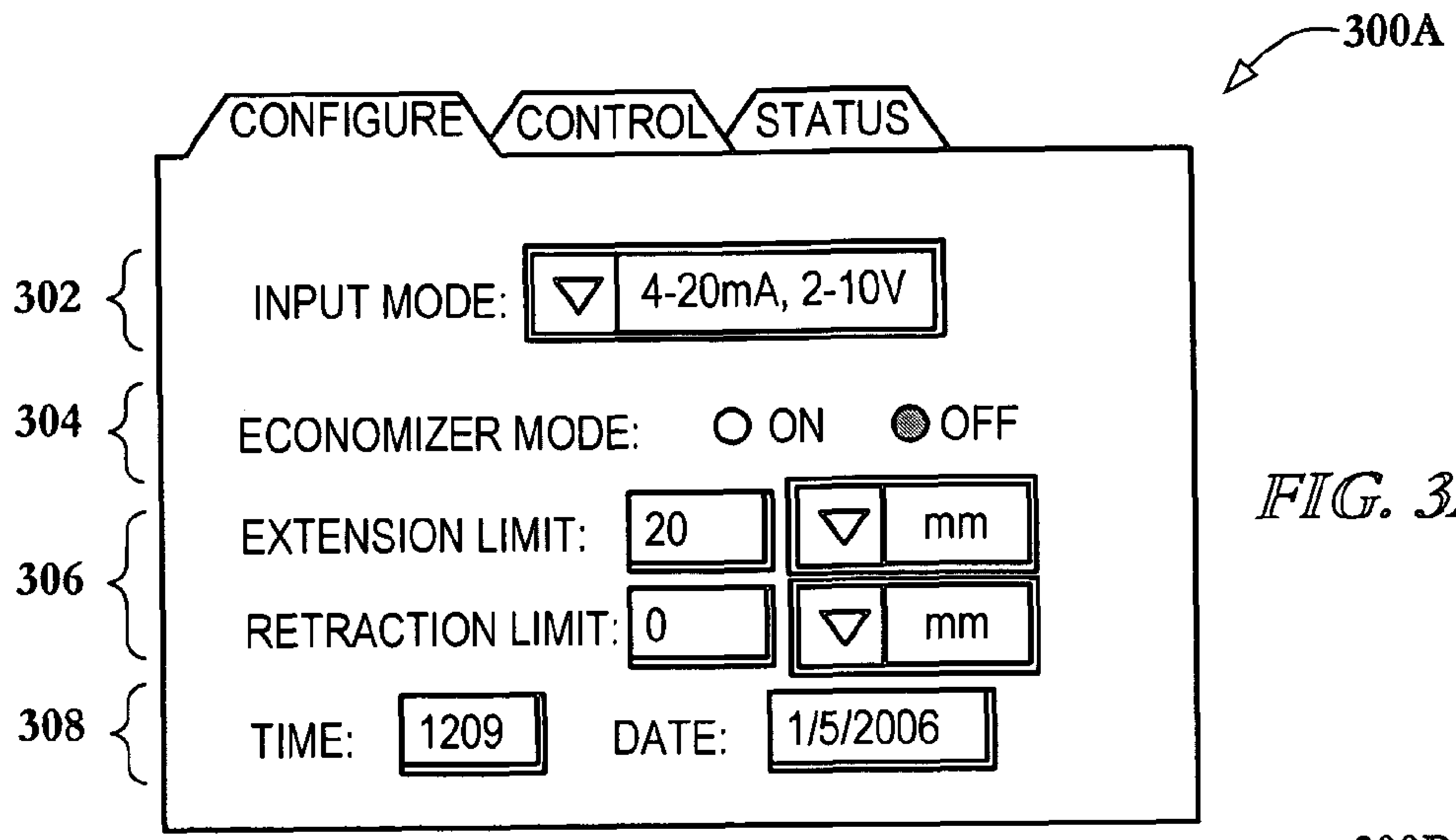


FIG. 3A

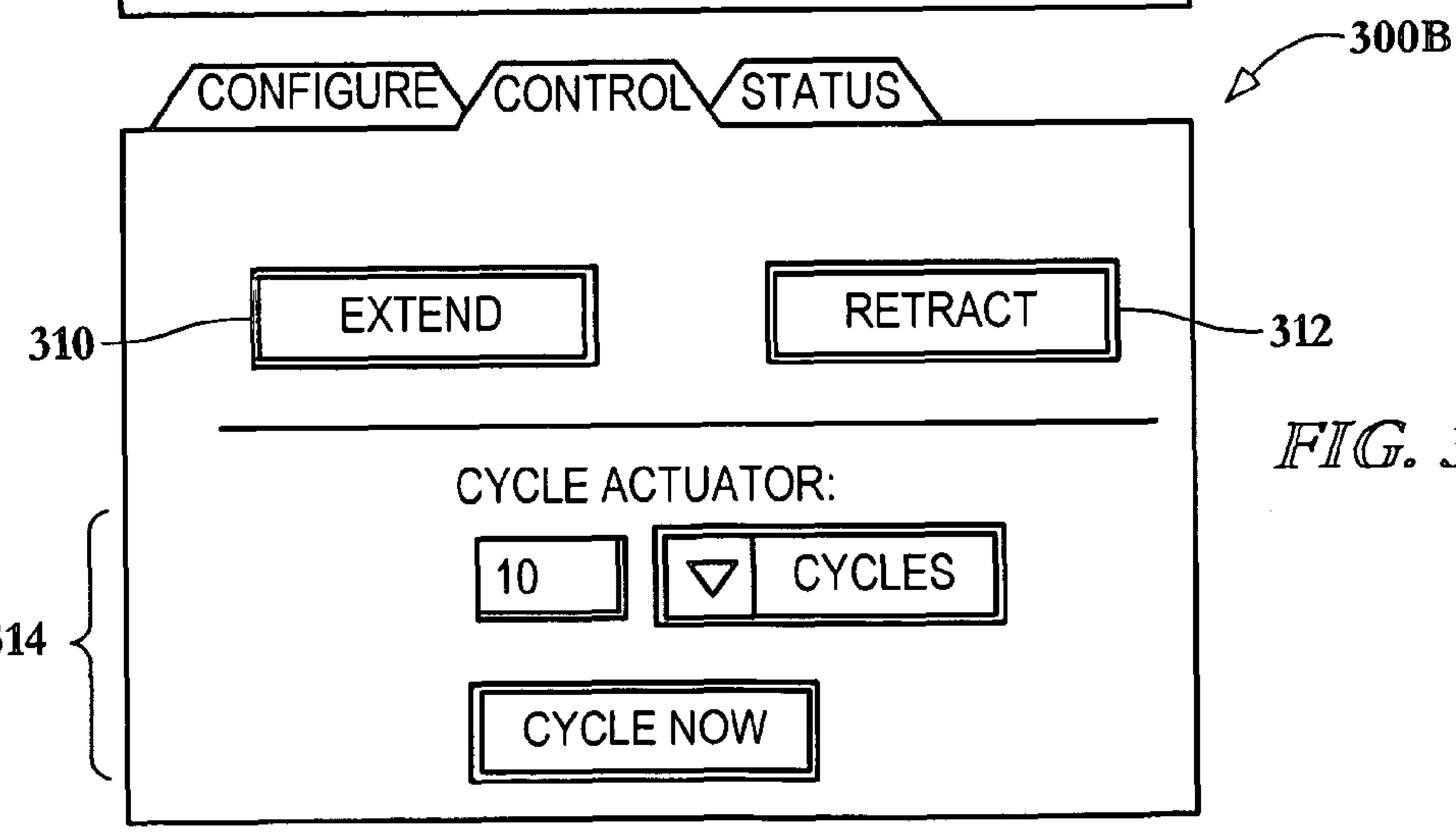


FIG. 3B

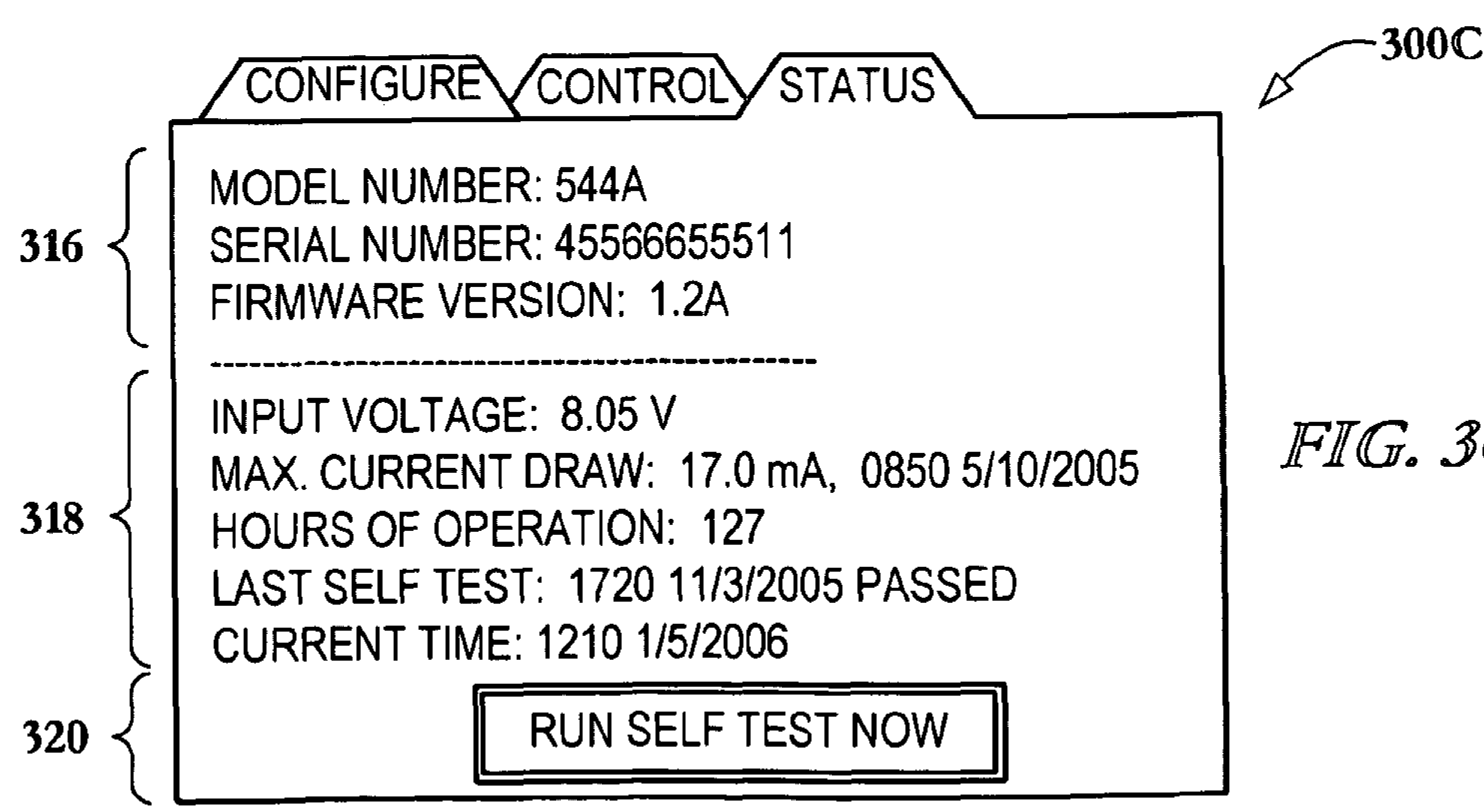


FIG. 3C

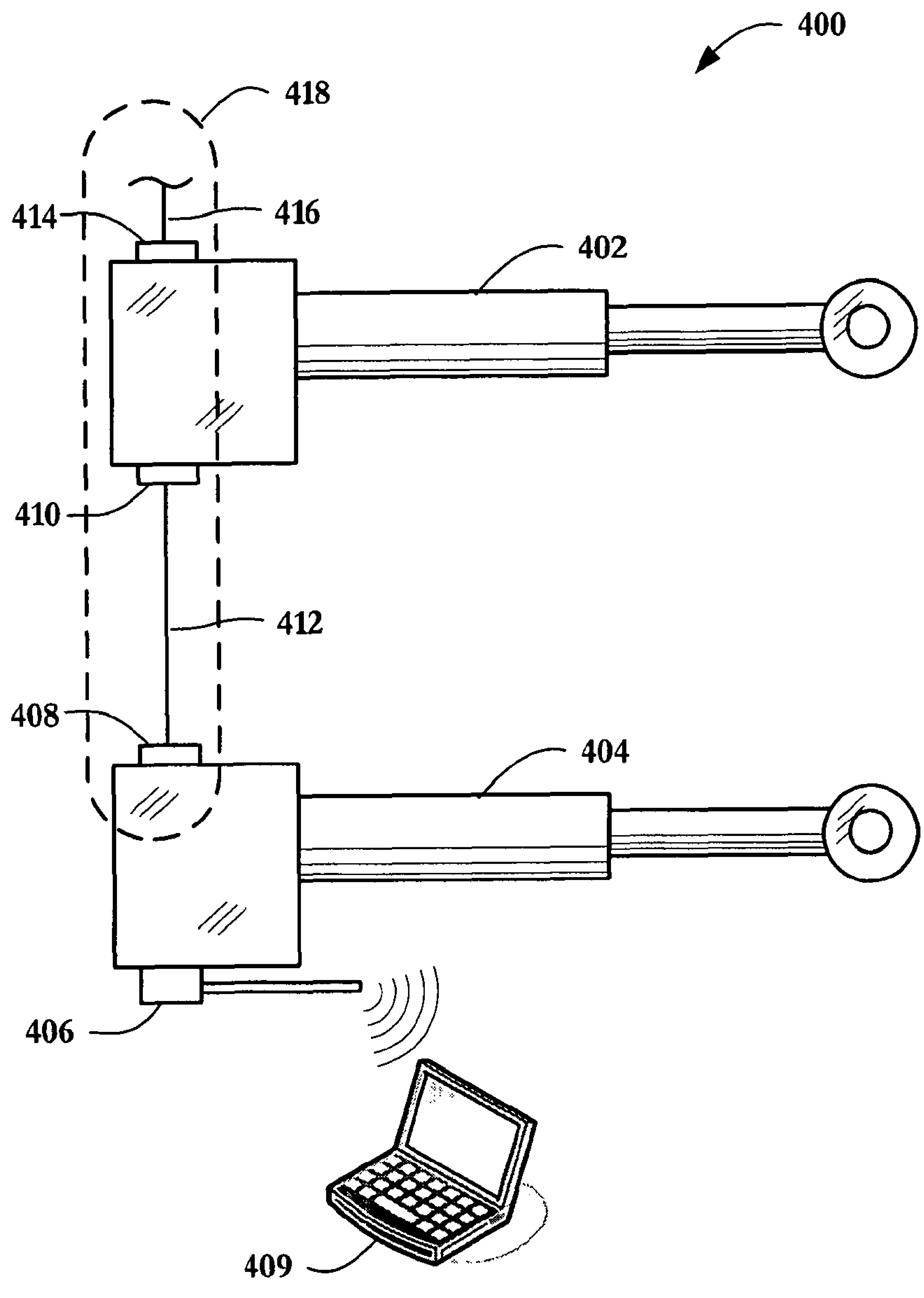


FIG. 4

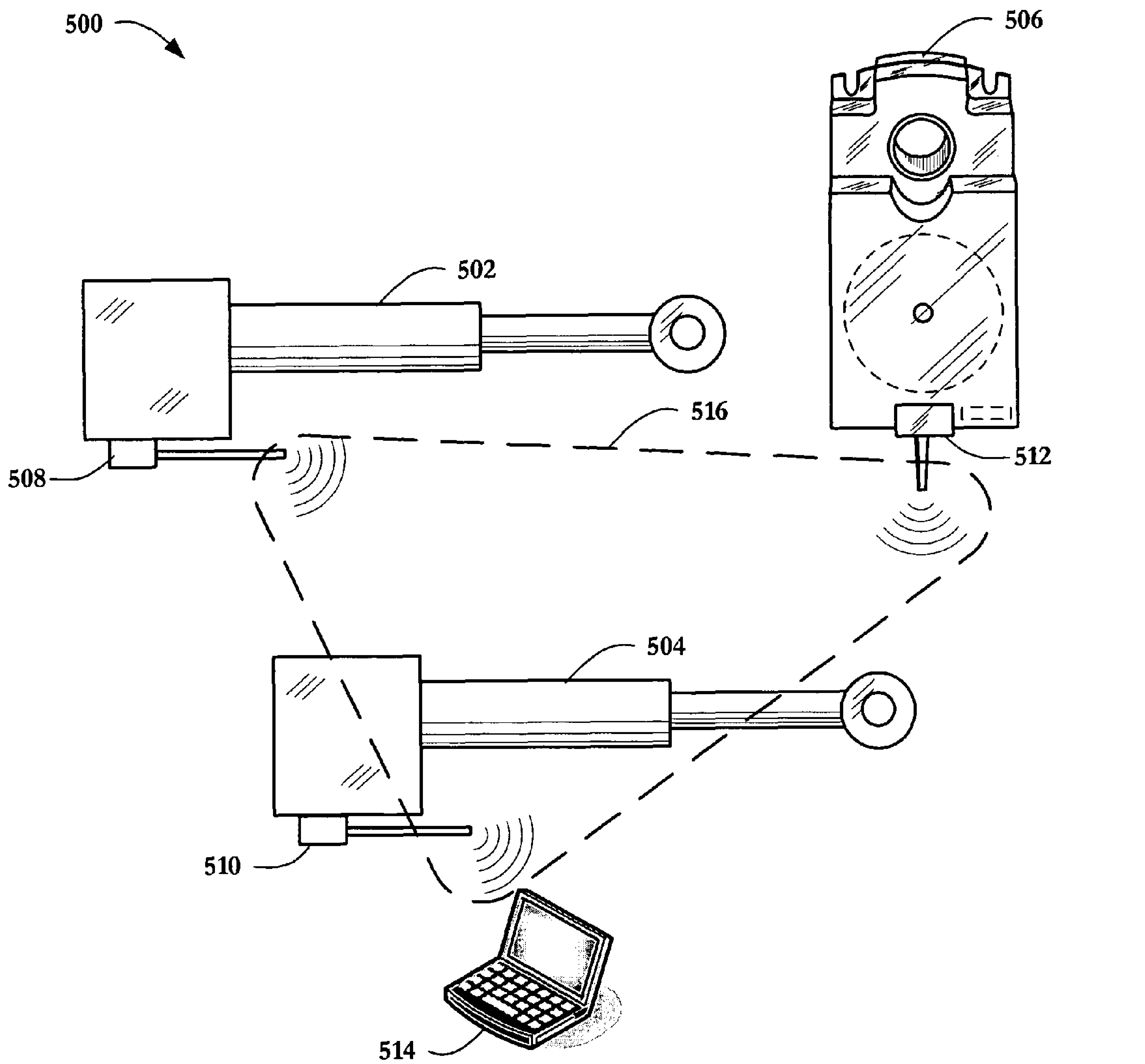
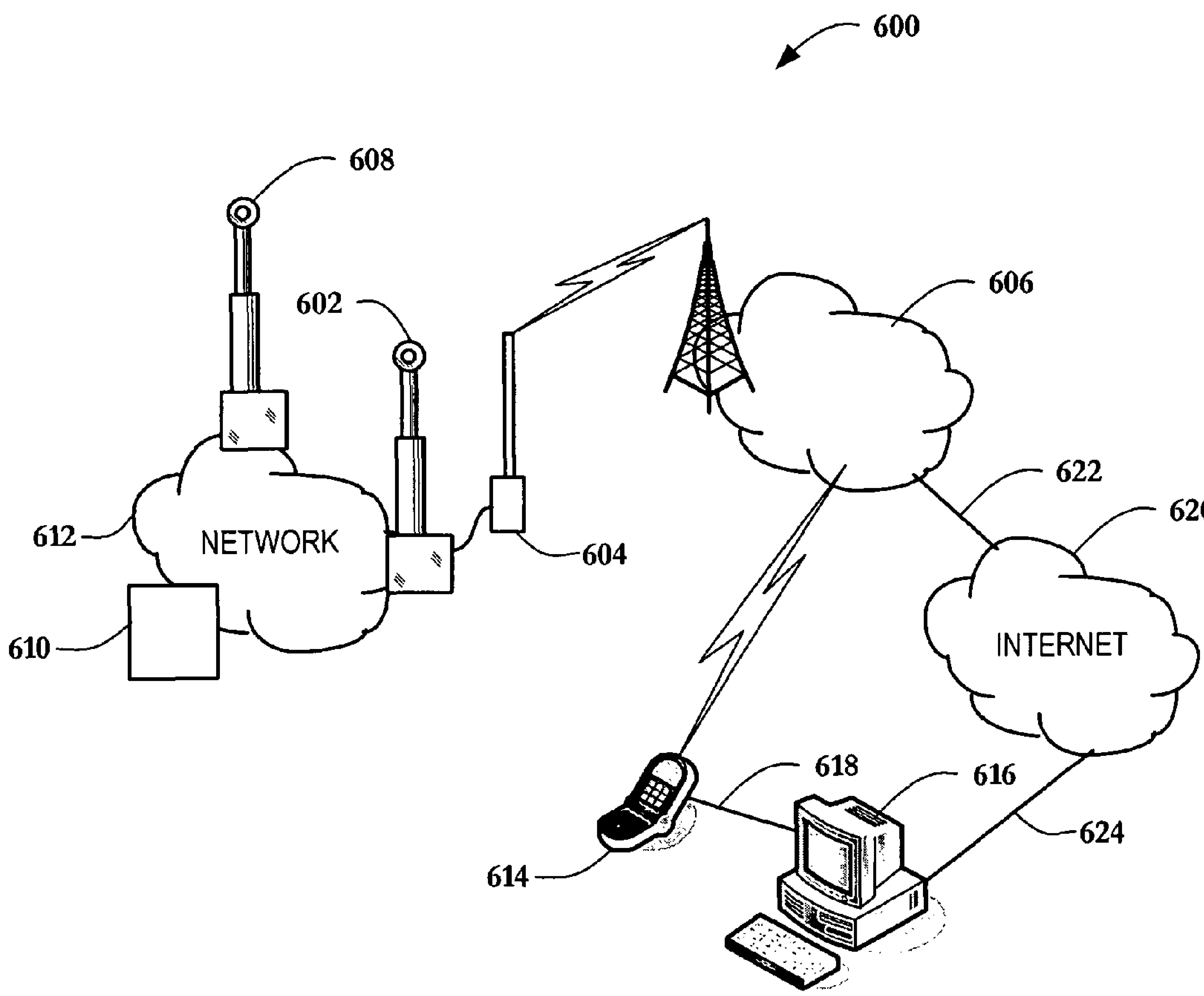


FIG. 5



600
608
602
606
612
NETWORK
604
622
620
610
INTERNET
618
616
614
624

FIG. 6

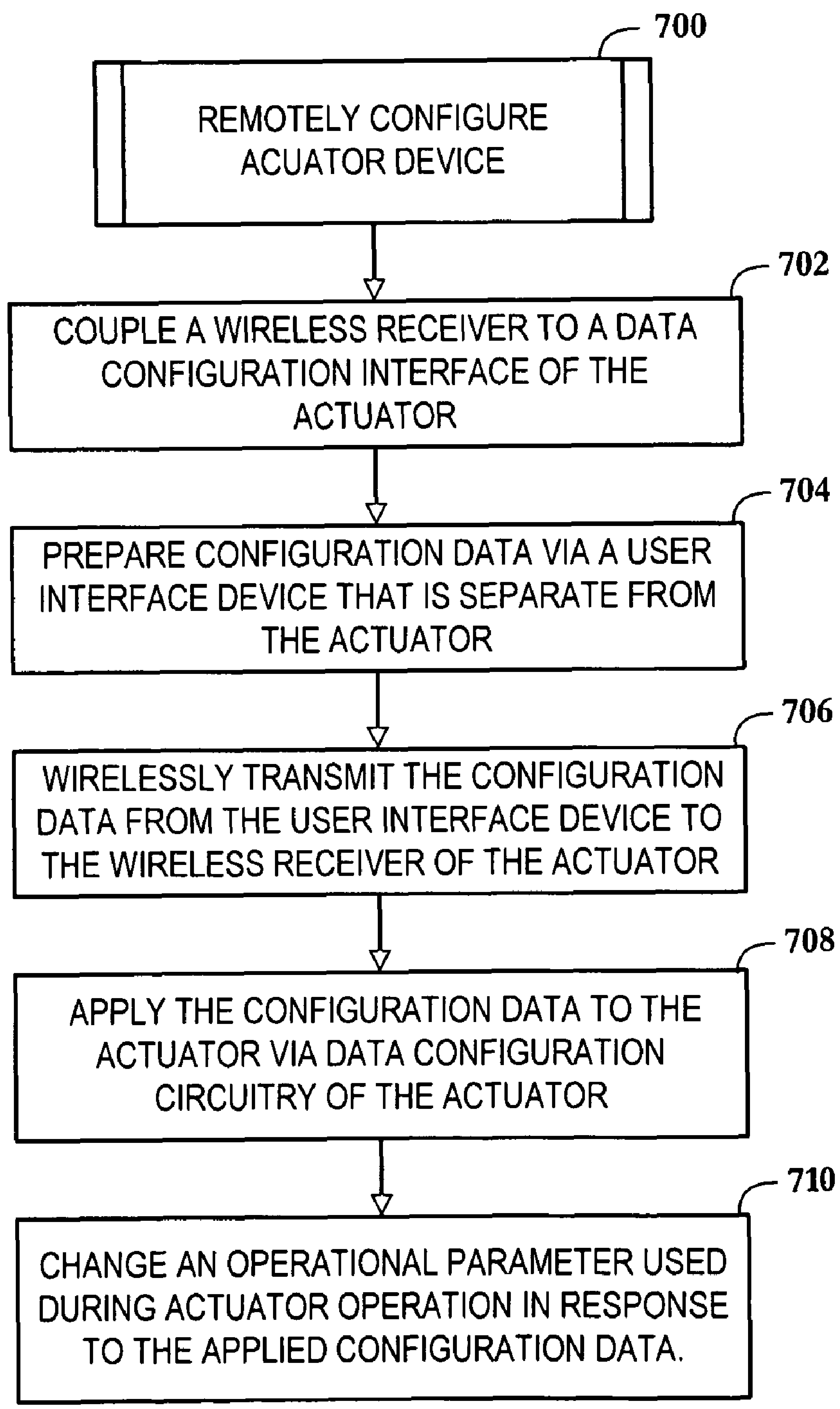

700
REMOTELY CONFIGURE ACUATOR DEVICE
702
COUPLE A WIRELESS RECEIVER TO A DATA CONFIGURATION INTERFACE OF THE ACTUATOR
704
PREPARE CONFIGURATION DATA VIA A USER INTERFACE DEVICE THAT IS SEPARATE FROM THE ACTUATOR
706
WIRELESSLY TRANSMIT THE CONFIGURATION DATA FROM THE USER INTERFACE DEVICE TO THE WIRELESS RECEIVER OF THE ACTUATOR
708
APPLY THE CONFIGURATION DATA TO THE ACTUATOR VIA DATA CONFIGURATION CIRCUITRY OF THE ACTUATOR
710
CHANGE AN OPERATIONAL PARAMETER USED DURING ACTUATOR OPERATION IN RESPONSE TO THE APPLIED CONFIGURATION DATA.

FIG. 7

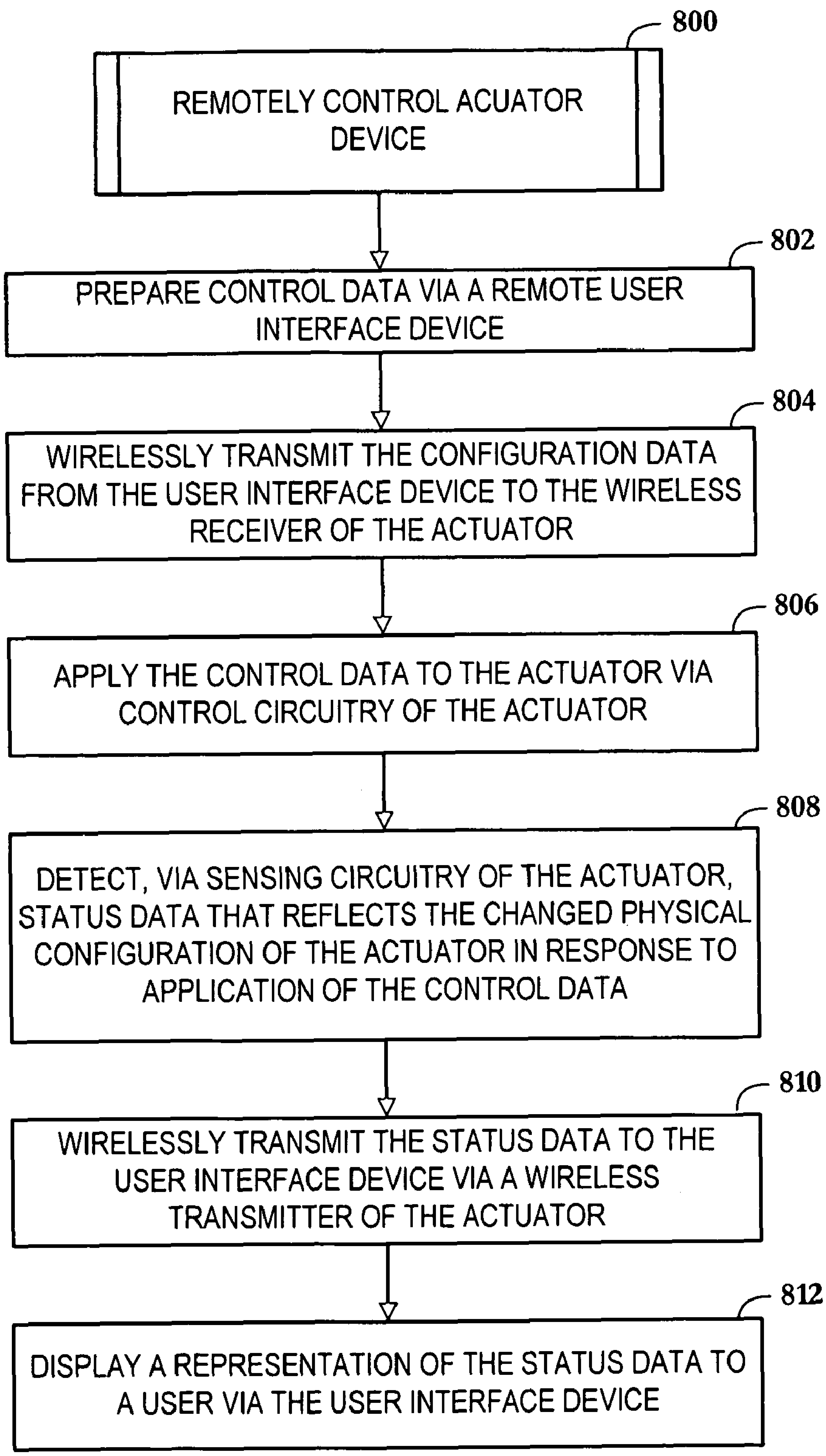

800
REMOTELY CONTROL ACUATOR DEVICE
802
PREPARE CONTROL DATA VIA A REMOTE USER INTERFACE DEVICE
804
WIRELESSLY TRANSMIT THE CONFIGURATION DATA FROM THE USER INTERFACE DEVICE TO THE WIRELESS RECEIVER OF THE ACTUATOR
806
APPLY THE CONTROL DATA TO THE ACTUATOR VIA CONTROL CIRCUITRY OF THE ACTUATOR
808
DETECT, VIA SENSING CIRCUITRY OF THE ACTUATOR, STATUS DATA THAT REFLECTS THE CHANGED PHYSICAL CONFIGURATION OF THE ACTUATOR IN RESPONSE TO APPLICATION OF THE CONTROL DATA
810
WIRELESSLY TRANSMIT THE STATUS DATA TO THE USER INTERFACE DEVICE VIA A WIRELESS TRANSMITTER OF THE ACTUATOR
812
DISPLAY A REPRESENTATION OF THE STATUS DATA TO A USER VIA THE USER INTERFACE DEVICE

FIG. 8

WIRELESS ACTUATOR INTERFACE

FIELD OF THE INVENTION

This invention relates in general to industrial controls, and in particular to electronically configurable actuators.

BACKGROUND

Actuators are widely used in all areas of mechanical design. Generally, actuators are transducers that transform an input signal into mechanical motion. Actuators may use any combination of electrical motors, pneumatic and hydraulic pistons, relays, comb drives, piezoelectric elements, thermal bimorphs, and similar devices to provide mechanical motion. An actuator may provide any combination of linear, curved, or rotary forces/motion.

Motors are commonly used in actuators when circular motions are needed, but can also be used for linear applications by transforming circular to linear motion, e.g., using screw drives. Other actuators may intrinsically linear, such as those using linear motors. Actuators may include a wide variety of mechanical elements to change the nature of the motion provided by the actuating/transducing element, including levers, ramps, screws, cams, crankshafts, gears, pulleys, constant-velocity joints, ratchets, etc.

Actuators may vary widely in size and power. Very large actuators may be used in applications such as dam gates or construction equipment. On the other end of the spectrum, actuators have been developed at micro- and nano-scales that may be used for such applications as robotics and medical technology. One technological area that commonly uses actuators is industrial controls, including specialty areas of heating, ventilation, and air conditioning (HVAC) and fire detection/suppression.

Modern actuators used in HVAC and fire/smoke systems are becoming increasingly sophisticated. The added functionality is due at least in part to the availability of inexpensive and powerful digital processing circuitry. For example, actuators may have electronic controlled and integrated auxiliary switches, multiple input selectable input modes, and adjustments for such settings as minimum/maximum travel, timing, speed, etc. At the same time, the actuator products themselves are shrinking in size due to concerns regarding ease of installation, weight, power consumption, performance, etc. As a result, it is becoming more difficult to allow such actuators to be easily accessed by people for setting up and changing built-in automatic features of the actuators. In addition, externally mounted controls (e.g., switches, potentiometers, etc.) are often difficult to access and see in many installations. Further, hard mounted controls are susceptible to environmental factors (e.g., dust, fluids, vibration) that can degrade these types of controls and thereby reduce reliability.

Therefore, a sophisticated yet user friendly way of providing control and setup of actuators is desirable. Such control provisions should allow such actuators to keep small form-factors, and reduce the degrading effects of the operational environment. The present invention fulfills these and other needs, and offers other advantages over the prior art.

SUMMARY

The present disclosure relates to actuators, in particular to electronically configurable actuators. In one embodiment of the invention, an actuator includes a mechanical transducer component capable of applying a mechanical force to an external object in response to electronic signals. The actuator includes a communications interface capable of wirelessly receiving configuration data related to operation of the actuator. A settings module is coupled to the communications interface and capable of storing the configuration data. A controller unit is coupled to the mechanical transducer and the settings module. The controller unit is capable of determining the configuration data via the settings module and controlling the mechanical transducer in conformance with the configuration settings.

In more particular embodiments, the communications interface is capable of wirelessly receiving control data used to change a physical configuration of the mechanical transducer and communicate the control data to the controller unit. The physical configuration of the mechanical transducer is changed by the controller unit in response to receipt of the control data. The actuator may include a sensing unit capable of detecting sensor data representing the changed physical configuration of the mechanical transducer. The sensing unit is coupled to communicate the sensor data to communications module, and the communications module wirelessly transmits the sensor data.

In other, more particular embodiments, the communications module is capable of determining the stored configuration data and wirelessly transmitting the configuration data. The configuration data may include travel limits of the actuation member, speed of the mechanical transducer, timing parameters of the mechanical transducer, and/or electrical input ranges of the actuator.

In another embodiment of the invention, a method of configuring an actuator involves coupling a wireless receiver to a data configuration interface of the actuator. Configuration data is prepared via a user interface device that is separate from the actuator. The configuration data is wireless transmitted from the user interface device to the wireless receiver of the actuator. The configuration data is applied to the actuator via data configuration circuitry of the actuator. The data configuration circuitry changes an operational parameter used during actuator operation in response to the applied configuration data.

In more particular embodiments, the method further involves preparing control data via the user interface, wirelessly transmitting the control data from the user interface device to the wireless receiver of the actuator, and applying the control data to control circuitry of the actuator. The control circuitry changes a physical configuration of the actuator at in response to the control data being applied to the control circuitry. The method may also involve detecting, via sensing circuitry of the actuator, status data that reflects the changed physical configuration of the actuator in response to application of the control data, wirelessly transmitting the status data to the user interface device via a wireless transmitter of the actuator, and displaying a representation of the status data to a user via the user interface device.

In other, more particular embodiments, the method further involves storing the configuration data in a memory of the actuator in response to applying the configuration data to the actuator via the data configuration interface. The stored configuration may be stored via the data configuration circuitry of the actuator, wirelessly to the user interface device via a wireless transmitter of the actuator, a representation of the configuration data displayed to a user via the user interface device.

In another embodiment of the invention, a system includes a wireless device and an actuator. The wireless device includes a user interface that allows a user to specify configuration data and a wireless data interface capable of transmitting the configuration data. The actuator is capable of being

wirelessly exchanging data with the wireless device. The actuator includes a mechanical transducer capable of transmitting force to an external object in response to electronic signals, and a communications interface. The communications interface is capable of wirelessly receiving the configuration data from the wireless device. A settings module is coupled to the communications interface and capable of storing the configuration data. A controller unit is coupled to the mechanical transducer and the settings module, the controller unit capable of determining the configuration data via the settings module and controlling the mechanical transducer in conformance with the configuration settings.

In another embodiment of the invention, a system includes means for preparing configuration data via a user interface device, means for wirelessly transmitting the configuration data from the user interface device to a wireless receiver of an actuator, means for applying the configuration data to the actuator via data configuration circuitry of the actuator, and means for changing actuator operation in response to the applied configuration data.

In more particular embodiments, the system includes means for preparing control data via the user interface, means for wirelessly transmitting the control data from the user interface device to the wireless receiver of the actuator; and means for applying the control data to control circuitry of the actuator, wherein the control circuitry changes a physical configuration of the actuator at in response to the control data being applied to the control circuitry. The system may also include means for detecting, via sensing circuitry of the actuator, status data that reflects the changed physical configuration of the actuator in response to application of the control data, means for wirelessly transmitting the status data to the user interface device via a wireless transmitter of the actuator; and means for displaying a representation of the status data to a user via the user interface device.

These and various other advantages and features of novelty which characterize the invention are pointed out with particularity in the claims annexed hereto and form a part hereof. However, for a better understanding of the invention, its advantages, and the objects obtained by its use, reference should be made to the drawings which form a further part hereof, and to accompanying descriptive matter, in which there are illustrated and described representative examples of systems, apparatuses, and methods in accordance with the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is described in connection with the embodiments illustrated in the following diagrams.

FIG. **1** is a block diagram illustrating components of an actuator according to embodiments of the invention;

FIG. **2** is a perspective view of an example actuator system according to embodiments of the invention;

FIGS. **3**A-C are diagrams of user interface components that may be used to access data related to various aspects of actuator operation according to embodiments of the invention;

FIG. **4** is a diagram of a multi-actuator arrangement according to embodiments of the invention;

FIG. **5** is a diagram of an alternate multi-actuator arrangement according to embodiments of the invention;

FIG. **6** is a diagram of a long-range wireless actuator system according to embodiments of the invention;

FIG. **7** is a flowchart illustrating a procedure for remotely configuring an actuator according to embodiments of the present invention;

FIG. **8** is a flowchart illustrating a procedure for remotely controlling an actuator according to embodiments of the present invention.

DETAILED DESCRIPTION

In the following description of various exemplary embodiments, reference is made to the accompanying drawings that form a part hereof, and in which is shown by way of illustration various embodiments in which the invention may be practiced. It is to be understood that other embodiments may be utilized, as structural and operational changes may be made without departing from the scope of the present invention.

Generally, the present invention is directed to configuring and controlling actuators using an external user interface. The term "actuator," as used herein, includes any apparatus capable of providing forces and/or motion in response to an electrical control signal. Actuators may use any force transducer known in the art, including linear/rotary electrical motors, hydraulic or pneumatic pistons/motors, piezoelectric elements, etc. Electrical control signals may both actively control the actuator (e.g., movement commands) and be used to set system parameters (e.g., actuation limits, speeds). The electrical control signals may be generated internally, although at least a portion of the electrical signals originate from the external user interface. The external user interface may also be capable of operating in an interactive mode, such as to directly control the actuator, as well as in other capacities such as setting device parameters.

It will be appreciated that actuators described herein may not require any electrical control signal to cause the actuator to perform its basic functions (e.g., extend, retract, rotate), as these operations may be triggered in part by mechanical on non-electrical stimuli. However, some aspects of the actuator's operation will at least be indirectly affected by electrical control signals. For example, a hydraulic actuator may rely on a physical member to limit motion (e.g., a stop) that is adjusted by way of an electric motor. Thus, although the electrical motor may not be in operation when the actuator's motion is limited by the stop, the position of the stop was adjusted by way of electrical signals applied to the motor, thus signals to the motor indirectly control the behavior of the actuator.

Actuators as shown herein will generally have interfaces for accepting electrical signals at least for configuration of actuator parameters. The signals are provided at least in part by the external user interface. The external user interface generally includes a device that is physically separate from the actuator. In one embodiment, the external interface interacts with the actuator wirelessly. Use of a physically separate device for user interface enables the actuator to have sophisticated, flexible, and easy to understand controls, while still allowing the actuator to retain a small physical footprint and a utilize a mechanically simple exterior. Making the external interface wireless further simplifies the mechanical design, as no external connectors need be dealt with. Further, a wireless external interface is much easier to use when the actuator is mounted in a difficult to access location.

In reference now to FIG. **1**, a block diagram illustrates components of an actuator **100** according to embodiments of the invention. The actuator **100** includes an actuation member **102** that is used to apply forces and/or moments to external objects. In the HVAC and fire detection/suppression fields, the actuation member **102** is used to move objects, such as dampers, valves, etc. The actuation member **102** often includes mechanical apparatus such as gears **104** and bearings **106** that provide the desired forces. Typically, the forces produced by the actuation member **102** are used to produce motion, such as rotation **108**, linear translation **110**, or specialized paths, as represented by curve **111**. Those skilled in the art will appreciate that the actuator **100** need not always produce significant motion in operation. For example, the actuator **100** may be intended to exert a force or moment with little motion, such as in applying an opening/holding force to a door or other member.

The actuation member **102** is driven by a transducer **112**. The transducer **112** generally transforms one form of energy to another. In actuator applications, at least some of the energy is transformed into a mechanical force by the transducer **112**. Example transducers **112** may include electric motors **114**, valves **116**, pistons **118**, and solenoids **120**. It will be appreciated that the transducer **112** may be integrated with the actuation member **102**, such as where a piston rod is the actuation member for a piston **118**. Similarly, the transducer **112** may include many combinations of transducer components, such as a hydraulic piston **118** controlled by a solenoid-operated valve **116**. Transducers **112** may be used for other purposes besides movement of the actuation member. For example, mechanical setting such as extension limits or gear ratios may be automatically adjusted by way of one or more transducers **112**.

The actuator **100** includes provisions for controlling some aspects of its operation in response to electrical signals, as represented by the controller **122**. The controller **122** is an electronic unit that may be used to at least control settings applied to the actuator **100**, as well as for real-time control of the actuator **100**. The electrical signals are applied to the transducer **112**, either directly or indirectly, via a transducer interface **124**. The transducer interface **124** may include circuitry for amplifying and conditioning of signals **126** that are applied to electrical control portions of the transducer **112**. The transducer interface **112** may also include circuitry for receiving signals **128** generated by the transducers **112** and processing those signals **128** for use by other components of the controller **122**. An example of these latter signals **128** includes outputs of sensors that may be included or separate from the transducer **112**.

The controller **122** also may include a settings/control processor **130** that manages data on behalf of the actuator **100**. The settings/control processor **130** is coupled to the transducer interface **124** for sending and receiving transducer data. The settings/control processor **130** may also be coupled to a communications interface **132** that enables remote configuration and/or control of the actuator **100**. The settings/control processor **130** may include any combination of analog and digital circuitry. In one embodiment, the processor **130** may be provided as a custom digital state machine or a general purpose microprocessor. The processor **130** may include or have access to memory (not shown) for storing and retrieving data related to actuator operation.

The communications interface **132** allows an external device, such as an external user interface **134**, to affect the settings/control processor **130**. Although the communications interface **132** may use solid media such as wire or optical fiber to communicate with external devices **134**, the illustrated interface **132** includes the ability to communicate wirelessly, as indicated by signals **136**, **137**. The wireless interface **132** typically includes receiver circuitry for receiving and processing incoming signals **136**, and may also include transmitting circuitry for transmitting signals **137**.

Generally, the communications interface **132** allows the external user interface **134** (and similar devices) to apply configurations, query existing settings, query operational data (e.g., cycle counters, sensor data including position, force, temperature, etc), control the actuator, run self tests, etc. The communications interface **132** and user interface **134** may engage in one-way or two-way communications. Typically, the interfaces **132**, **134** will at least support a transmission from the user interface **134** to the actuator **100**. However, in order to confirm that configuration changes and other communications were successful, a transmission from the actuator **100** (via the communications interface **132**) to the user interface device **134** is desirable.

The wireless signals **136**, **137** may include any wireless communication medium known in the art, including radio, light, and sound transmissions. The signals **136**, **137** may operate at a single transmission frequency, or at multiple transmission frequencies, including the use of spread spectrum transmission technologies. The signals **136**, **137** may be encoded with any type of modulation, including amplitude, frequency, and phase shift. The transmission media type of signals **136**, **137** and are chosen based on factors generally known in the art, including cost, installation requirements (e.g., whether line-of-sight with communications interface is available), bandwidth, existence of interference, power consumption, etc.

The external user interface **134** includes one or more wireless interfaces compatible with the communications interface **132** of the actuator **100**. The external user interface **134** may be implemented using a general purpose device, such as a portable computer, PDS, cellular phone, etc. Such a device may be programmable for any number of different actuators **100**, and similar devices. The external interface **134** may also include custom designed hardware that is compatible with a particular actuator **100** or set of actuators.

The external user interface **134** generally includes a human-machine interface that includes input devices **138** and output devices **140**. Input device **138** are used to accept user input for such purposes as applying actuator settings, actuator control, menu navigation, setup of the interface device **134**, etc. Input devices **138** may include devices such as buttons, keypads, dials, wheels, motion sensors, voice recognition, etc. The output device **140** shows the results of user inputs, actuator status, current actuator settings, settings/status of the interface device **134**, etc. The output device **140** may include video displays, alphanumeric displays, light emitting diodes (LEDs), liquid crystal displays (LCDs), speakers, tactile feedback devices, etc.

A more particular example of an actuator system **200** according to an embodiment of the invention shown in the perspective view of FIG. **2**. The example system **200** includes a rotary actuator **202** driven by an electric motor **204**. A rotary coupling **206** is driven by the electric motor **204**, either directly or by intermediate apparatus such as gears, pulleys, or wheels (not shown). The rotary coupling **206** acts as an actuation member that may be coupled to a shaft or other member for purposes of automated control.

The electric motor **204** of the actuator **202** is electrically coupled to control circuitry **208**, which includes an electrical interface (e.g., amplifiers, buffers), control circuitry (e.g., digital logic) and power circuitry. The control circuitry **208** may include one or more printed circuit cards, as well as off-card components, such as limit switches, sensors, etc. The control circuitry **208** also includes the capability to access and apply various settings associated with the motor **204** and circuitry **208**. These settings may be stored using any mechanical or electrical mechanism known in the art. For example, where the settings affect an adjustable mechanical component, the settings may be determined by sensing the current configuration or state of the component. More commonly, however, the circuitry **208** includes some sort of non-volatile digital memory (e.g., flash memory) that allows various operational parameters to be stored such that the data is not lost if power is removed.

The control circuitry **208** may include a default or failsafe set of parameters that govern the operation of the actuator **202** in the absence of any user settings. However, the end-user will often want to modify settings, either before or after the actuator is installed. To allow a convenient adjustment of the actuator **202**, a wireless interface **210** is coupled to control circuitry **208**. The wireless interface **210** includes an antenna/receptor **212** that allows signals **214** to be sent and received for purposes of affecting operation of the control circuitry **208**.

The illustrated wireless interface **210** is fixed to the housing of the actuator **202**. However, it may be advantageous to alternately provide a removable wireless interface, such as removable interface **216**. The removable interface **216** may include similar components as the fixed interface **210**, including a wireless antenna/receptor **218**. The removable interface **216** also includes a connector **220** that mates with a matching receptacle **222** on the actuator **200**. The connector **220** and/or receptacle **222** may also include structural members, such as fasteners, clips, threads, etc., that allows the interface **216** to be fixably coupled to the actuator **202**. In other arrangements, the removable wireless interface **216** may be coupled to the receptacle **222** via a cable (not shown) that allows the interface **216** to be mounted distantly from the actuator **202**. Such an arrangement may be advantageous in some situations, such as where the actuator **200** is mounted in an enclosure that is impermeable to light or radio waves.

Regardless of whether the actuator **202** includes a fixed wireless interface **210** and/or a removable interface **216**, the end user may utilize a user interface device **224** in order to configure the control circuitry **208** via one or both of the wireless interfaces **210**, **216**. The illustrated user interface device **224** is a standard portable processing device, such as a PDA or ultra-mobile personal computer (PC). The interface device **224** includes an antenna/receptor **226** compatible with the wireless interface(s) **210**, **216** of the actuator **200**. The user interface device **224** includes buttons **228** for accepting user input, and a display **230** for presenting user output.

A user interface device **224** may use a variety of user input and output arrangements. General purpose computing devices such as the illustrated device **224** allow a graphical user interface (GUI) to be inexpensively implemented. A GUI can be user friendly, yet still capable of providing sophisticated and flexible access to the underlying configurations and operations of the actuator system **200**. Example embodiments of actuator configuration GUIs **300**A-C according to embodiments of the invention are shown in FIGS. **3**A-C.

The GUIs **300**A-C represent various panels of a tabbed interface that may be used to access data related to various aspects of actuator operation. Panel **300**A illustrates an exemplary configuration interface, panel **300**B illustrates an exemplary control interface, and panel **300**C illustrates an exemplary status/test panel. The configuration interface **300**A includes controls for setting actuator parameters such as voltage/current input mode **302**, economizer mode **304**, extension/retraction limits **306**, time/date **308**.

The controls panel **300**B provides controls for such real-time, active actuator control, such as extension/retraction buttons **310**, **312** and controls **314** that enable the running of multiple extension/retraction cycles. The status/test panel **300**C includes relatively static configuration data **316** such as model number, serial number, and firmware/software version. Operational status data **318** may also be shown in the status/test panel **300**C, which may show such data as input voltage, historical data (e.g., maximum current usage, run time, self tests), current date/time, etc. The status/test panel **300**C may also allow the user to run actuator self tests, as represented by button **320**. Those skilled in the art will appreciated that the example GUIs **300**A, **300**B, **300**C are exemplary, the selection, arrangement, and type of controls within a configuration GUI, as well as underlying content can vary from those illustrated. For example, similar functionality may be provided using a text-based menu on a dot-matrix LED or LCD text display.

In the illustrated embodiments above, a wireless interface is used to set and receive configuration data relating to a single actuator. In multi-actuator systems, each actuator may have a separate integral or plug-in wireless adapter, each separately accessible and addressable from a wireless user interface device. An alternate multi-actuator arrangement **400** according to an embodiment of the invention is shown in FIG. **4**. The illustrated arrangement includes two independently operable linear actuators **402** and **404**. The actuator **404** includes a wireless adapter **406** that is accessible from a wireless user interface device, here represented by laptop computer **408**. The actuator **404** also includes a wired interface **408** that is capable of being coupled to a wired interface **410** of actuator **402** via a cable **412**. Actuator **402** also includes another wired interface **414** capable of being coupled to another actuator (not shown) via cable **416**, and so on.

Generally, the wired interfaces **408**, **410**, **414** and cables **412**, **416** can form a wired data bus **418** capable of managing a plurality of actuators, as well as other control devices. For example, the bus **418** could interface with devices such as switches, sensors, thermostats, controls, smoke detectors, temperature sensors, etc. The wireless interface **406** is also coupled to the wired bus **418**, thereby allowing access to a large number of components via a conveniently accessible wireless device **409**. The bus **418** could communicate via dedicated signal wires, or "piggyback" data on top of other conductive paths, such as power wires.

The bus **418** in FIG. **4** utilizes conductors to share data between multiple devices for single access via a wireless user interface device. In some situations, it may be desirable to allow wireless devices to be similarly coupled onto a common, logical network that may only need a single point of entry. An arrangement **500** that uses a wireless network according to an embodiment of the invention is shown in FIG. **5**. In this arrangement, three actuators, Linear actuators **502**, **504** and rotary actuator **506**, each include respective wireless interfaces **508**, **510**, **512**. A wireless user interface device **514** is wirelessly coupled to at least one of the actuator wireless interfaces **508**, **510**, **512**. The actuators **502**, **504**, **506** may interact to form a relay or mesh network, wherein at least some of the actuators **502**, **504**, **506**, pass data on behalf of others of the actuators **502**, **504**, **506**. Wireless mesh networks are designed to handle many-to-many connections between wireless nodes and are capable of dynamically altering the connections as needed. As a result, mesh networks can use distributed devices to provide long range, self-healing data paths to the nodes of the network, and offer other advantages over traditional point-to-point or broadcast wireless connections.

In the illustrated embodiments, the wireless technologies included with actuators may include standard or proprietary short range data transfer protocols. Examples of such protocols include Bluetooth, IrDA, IEEE 802.11 wireless local area networks (WLAN), HomeRF, etc. These technologies generally utilize low power, close range or line of sight wireless transmissions. In alternate arrangements, however, an actuator according to embodiments of the invention may use long range wireless technologies, as exemplified by cellular network providers and mobile digital service providers. A long-range wireless solution can provide configuration and setup of actuators and related equipment from nearly anywhere.

In reference now to FIG. **6**, a long-range wireless actuator system **600** according to embodiments of the invention is illustrated. The system **600** includes at least one actuator **602** that includes a long range wireless interface **604**. This interface **604** may utilize digital or analog transmissions, and generally relies on a wireless infrastructure for support, as represented by wireless provider network **606**. The wireless interface **604** may be physically attached to the actuator **602**, or may be physically separate and coupled via a cable or other transmission media.

The actuator **602** may be a standalone device, or may be connected to other actuators **608** and other devices **610** by a common bus or network **612**. The long range wireless interface **604** may provide remote access to any device **602**, **608**, **610** coupled by the bus or network **612**. A user interface may be provided in a device that utilizes the provider network **606** directly, such as a cellular phone **614** or PDA (not shown). In another arrangement, the cellular phone **614** may act as a communication interface between the provider network **606** and another device, such as personal computer **616**, as indicated by path **618**. In an alternate arrangement, the provider network **606** may be coupled to the Internet **620** (or other large scale network), thus allowing the computer **616** to access the actuator configuration(s) directly, as indicated by paths **622**, **624**.

In reference now to FIG. **7**, a flowchart illustrates a procedure **700** for remotely configuring an actuator according to embodiments of the present invention. A wireless receiver is coupled **702** to a data configuration interface of an actuator. Configuration data is prepared **704** via a user interface device that is separate from the actuator. The configuration data is wirelessly transmitted **706** from the user interface device to the wireless receiver of the actuator. The configuration data is applied **708** to the actuator via data configuration circuitry of the actuator. The data configuration circuitry changes **710** an operational parameter used during actuator operation in response to the applied configuration data.

In reference now to FIG. **8**, a flowchart illustrates a procedure **800** for remotely controlling an actuator according to embodiments of the present invention. Control data is prepared **802** via a user interface device. The control data is wirelessly transmitted **804** from the user interface device to a wireless receiver of the actuator. The control data is applied **806** to control circuitry of the actuator. The control circuitry changes a physical configuration of the actuator at substantially the same time as the control data is applied to the control circuitry. Sensing circuitry of the actuator may detect **808** status data that reflects the changed physical configuration of the actuator in response to application of the control data. The status data is wirelessly transmitted **810** to the user interface device via a wireless transmitter of the actuator. A representation of the status data is displayed **812** to a user via the user interface device.

Hardware, firmware, software or a combination thereof may be used to perform the various functions and operations described herein for controlling actuator hardware. Articles of manufacture encompassing code to carry out functions associated with the present invention are intended to encompass a computer program that exists permanently or temporarily on any computer-usable medium or in any transmitting medium which transmits such a program. Transmitting mediums include, but are not limited to, transmissions via wireless/radio wave communication networks, the Internet, intranets, telephone/modem-based network communication, hard-wired/cabled communication network, satellite communication, and other stationary or mobile network systems/communication links. From the description provided herein, those skilled in the art will be readily able to combine software created as described with appropriate general purpose or special purpose computer hardware to create a system, apparatus, and method in accordance with the present invention.

The foregoing description of the exemplary embodiment of the invention has been presented for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed. Many modifications and variations are possible in light of the above teaching. It is intended that the scope of the invention be limited not with this detailed description, but rather determined by the claims appended hereto.

What is claimed is:

1. An actuator, comprising:

a mechanical transducer component capable of applying a mechanical force to an external object in response to electronic signals;

a wireless communications interface including at least a wireless receiver capable of wirelessly receiving data related to operation of the actuator and to operation of one or more external devices that are distinct from both the actuator and an entity originating the data;

a settings module coupled to the wireless communications interface and capable of storing the data;

a wired interface coupled to the wireless communications interface and capable of wired bus communications with the one or more external devices via a wired bus, wherein the wired interface is capable of managing the one or more external devices in response to the data received wirelessly via the wireless communications interface; and

a controller unit coupled to the mechanical transducer and the settings module, the controller unit configured to control the mechanical transducer in conformance with the stored data.

2. The actuator of claim **1**, wherein the wireless communications interface is capable of wirelessly receiving control data used to change a physical configuration of the mechanical transducer and communicate the control data to the controller unit, wherein the physical configuration of the mechanical transducer is changed by the controller unit in response to receipt of the control data.

3. The actuator of claim **2**, further comprising a sensing unit capable of detecting sensor data representing the changed physical configuration of the mechanical transducer, wherein the sensing unit is coupled to communicate the sensor data to the wireless communications interface, wherein the wireless communications interface wirelessly transmits the sensor data.

4. The actuator of claim **1**, wherein the wherein the wireless communications interface is capable of determining the stored data and wirelessly transmitting the data.

5. The actuator of claim **1**, wherein the data includes travel limits of the mechanical transducer component.

6. The actuator of claim **1**, wherein the data include speed of the mechanical transducer.

7. The actuator of claim **1**, wherein the data include timing parameters of the mechanical transducer.

8. The actuator of claim **1**, wherein the data include electrical input ranges of the actuator.

9. The actuator of claim **1**, wherein the wired bus comprises a power bus.

10. The actuator of claim **1**, wherein the one or more external devices comprise devices operating in one of a group comprising heating, ventilation, and air conditioning (HVAC), and fire detection/suppression.

11. The actuator of claim **1**, wherein the one or more external devices comprise one or more other actuators.

12. The actuator of claim **1**, wherein the one or more external devices comprise one or more sensors.

13. The actuator of claim **1**, wherein the communications interface comprises a long-range wireless interface.

14. The actuator of claim **13**, wherein the long-range wireless interface comprises a wireless telephony interface.

15. The actuator of claim **1**, wherein the communications interface comprises a removable wireless receiving portion, wherein the removable wireless receiving portion is mountable distantly from the actuator to improve reception of wireless signals.

16. A system, comprising:

a wireless device comprising,

a user interface that allows a user to specify configuration data; and

a wireless data interface capable of transmitting the configuration data; and

an actuator capable of wirelessly exchanging data with the wireless device, the actuator comprising,

a mechanical transducer capable of transmitting force to an external object in response to electronic signals;

a wireless communications interface including at least a wireless receiver, the communications interface capable of wirelessly receiving from the wireless device the configuration data related to operation of both the actuator and one or more external devices that are distinct from the actuator and that are distinct from the wireless device;

a settings module coupled to the wireless communications interface and capable of storing the configuration data;

a wired interface coupled to the wireless communications interface and capable of wired bus communication with the one or more external devices via a wired bus, wherein the wired interface is capable of managing the one or more external devices in response to configuration data received wirelessly from the wireless device; and

a controller unit coupled to the mechanical transducer and the settings module, the controller unit configured to control the mechanical transducer in conformance with the configuration data.

17. The system of claim **16**, wherein the communications interface of the actuator is capable of wirelessly receiving control data from the wireless device, the control data used to change a physical configuration of the mechanical transducer, wherein the communications interface communicates the control data to the controller unit, and wherein the physical configuration of the mechanical transducer is changed by the controller unit in response to receipt of the control data.

18. The system of claim **17**, wherein the actuator further comprises a sensing unit capable of detecting sensor data representing the changed physical configuration of the mechanical transducer, wherein the sensing unit is coupled to communicate the sensor data to communications module, wherein the communications interface wirelessly transmits the sensor data to the wireless device for purposes of representing the sensor data to the user.

19. The system of claim **16**, wherein the configuration data include travel limits of the mechanical transducer.

20. The system of claim **16**, wherein the configuration data include speed of the mechanical transducer.

21. The system of claim **16**, wherein the configuration data include timing parameters of the mechanical transducer.

22. The system of claim **16**, wherein the configuration data include electrical input ranges of the actuator.

23. A system comprising:

means for preparing configuration data related to an actuator, and to one or more external devices distinct from the actuator, via a user interface device;

means for wirelessly transmitting the configuration data and the secondary configuration data from the user interface device to a wireless receiver of the actuator;

means for applying at least some of the configuration data to the actuator via data configuration circuitry of the actuator;

means for changing actuator operation in response to the applied configuration data;

means for communicating at least some of the configuration data to the one or more external devices via a wired bus and by way of the actuator for managing the one or more external devices, in response to wirelessly receiving the configuration data, wherein the one or more external devices are distinct from the actuator, the means for preparing the configuration data, and the means for wirelessly transmitting the configuration data.

24. The system of claim **23**, further comprising:

means for preparing control data via the user interface;

means for wirelessly transmitting the control data from the user interface device to the wireless receiver of the actuator; and

means for applying the control data to control circuitry of the actuator, wherein the control circuitry changes a physical configuration of the actuator at in response to the control data being applied to the control circuitry.

25. The system of claim **24**, further comprising:

means for detecting, via sensing circuitry of the actuator, status data that reflects the changed physical configuration of the actuator in response to application of the control data;

means for wirelessly transmitting the status data to the user interface device via a wireless transmitter of the actuator; and

means for displaying a representation of the status data to a user via the user interface device.

26. A method comprising:

wirelessly receiving, at an actuator, configuration data related to operation of the actuator and related to operation of one or more external devices that are distinct from the actuator and that are distinct from an entity originating the configuration data, wherein the one or more external devices are coupled via a wired bus to a wired interface of the actuator;

storing the configuration data at the actuator;

controlling a mechanical transducer in conformance with at least some of the configuration data, wherein the mechanical transducer component is capable of applying a mechanical force to an external object in response to electronic signals; and

managing the one or more external devices via the wired bus in response to at least some of the configuration data received wirelessly via the communications interface.

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